# NEOCLASSICAL THEORY AND AUSTRALIAN BUSINESS INVESTMENT: A REAPPRAISAL*

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## Abstract

This paper provides an attempt to reconcile neoclassical theory with Australian investment data. We argue that, by focusing almost exclusively on the demand for capital services, neoclassical investment theory neglects two related decisions: the decision to own the existing capital stock, and the decision to produce new capital goods. We propose a simple model of investment behaviour that integrates production decisions with portfolio decisions. Careful consideration is given to the determination of the price of capital, the rental price of capital, and the return on capital. The model is estimated by FIML, and a number of simulation results are reported.

## 1. Introduction

It has long been recognised that business investment is an important yet very volatile component of aggregate demand. As such it plays an important role in determining the level of real activity and the cyclical behaviour of the economy. Naturally, business investment is also crucial in shaping the growth path of the economy.

Because it is so volatile, business investment is difficult to model. Many theories of investment behaviour have been proposed in the literature, and have been applied with some success to Australian data. In recent years, however, business investment in Australia has eluded attempts to explain it. As shown in Figure 1, business investment has stagnated during most of the first half of the seventies. (It actually fell as a ratio to GDP.) It then fell sharply in the aftermath of the first oil shock; it shot up during 1980 and 1981, only to drop sharply again in 1982-83.

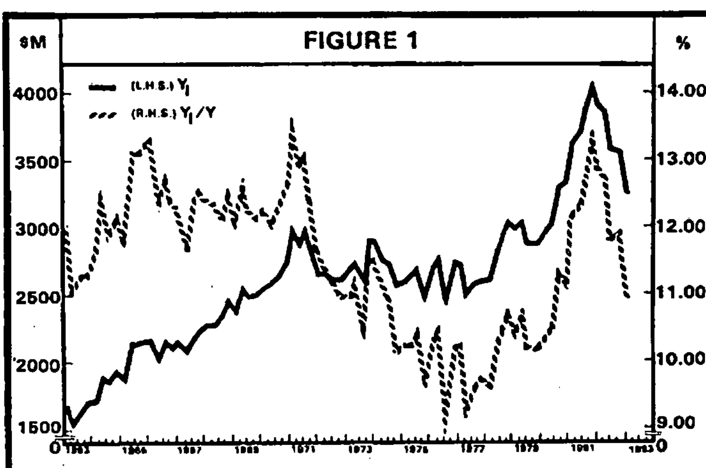
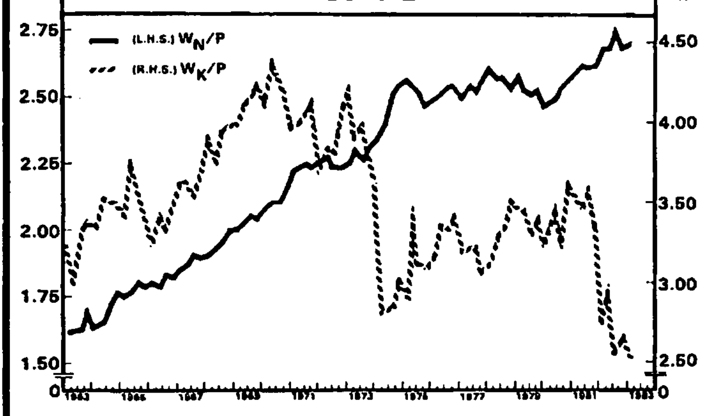



FIGURE 1

Existing models of investment behaviour have been at a loss to explain the ups and downs of Australian business investment. Flexible accelerator models have generally done best in tracking Australian investment, but their performance has deteriorated significantly recently.[1] As for neoclassical models, they have performed poorly quite consistently in Australia.[2] Moreoever, it is sometimes argued that the evidence of the 1970's does not support neoclassical investment theory.[3] The seventies were characterised in Australia by a substantial increase in real wages (Figure 2) and in the relative rental price of labour. This should have led to an increase in the desired capital/labour ratio, and it should have triggered, the argument goes, an increase in investment. Yet it is the opposite that occurred as noted above.

FIGURE 2




1. See Higgins et al. (1976) for instance.

2. See Higgins et al. (1976), Norton and Henderson (1972), and Hawkins (1979).

3. Hawkins (1979).

This paper attempts to reconcile neoclassical theory with the facts. We argue that it is not neoclassical theory that is at fault, but rather the use to which it has been put. However, the standard neoclassical model may be too simple to explain the Australian facts, and we extend it in a number of directions. In particular an attempt is made to integrate the investment decision with other related decisions.

The paper proceeds as follows. In Section 2 we briefly review neoclassical investment theory, and an interpretation of the poor performance of the model is suggested. In Section 3 we construct an integrated model of investment behaviour that seems consistent with the facts. Empirical implementation of the model is undertaken in Section 4. Section 5 reports a number of simulation results, and Section 6 contains our conclusions.

## 2. Neoclassical Investment Theory: Traditional Approach and Interpretation

Neoclassical investment theory is mostly due to the work of Jorgenson.[4] Assuming cost minimisation, Jorgenson derives the desired stock of capital from a Cobb-Douglas production function:

$$x_K^* = \alpha py/w_K \qquad (1)$$

$x_K^*$ is the desired stock of capital,[5] p is the price of output, y is the level of output, $w_K$ is the rental price of capital,[6] and $\alpha$ is the elasticity of output with respect to the capital stock.

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4. See Jorgenson (1963) and subsequent papers by the same author.

5. Throughout the paper, we assume that capital services are proportional to the capital stock. The two concepts can be used interchangeably through appropriate choice of measurement units.

6. Defined in the appendix.

Net investment is then assumed to be a distributed lag function of the change in the desired stock of capital, and gross investment can be obtained by adding replacement investment. The resulting equation has been estimated with Australian data on a number of occasions, but the results have generally been very poor. Our own estimates have proved to be no exception: we have been unable to detect a significant role for the relative price term $(p/w_K)$. On several occasions, this variable even entered the estimating equation with the wrong sign.[7] This result is of course inconsistent with the hypothesis of a Cobb-Douglas production function.

The poor performance of the neoclassical model is not only very disappointing, but it is also somewhat surprising. Indeed, there is ample empirical evidence, for Australia and elsewhere, supporting the hypothesis that capital and labour can be substituted for each other in production. It is rather odd, therefore, that the flexible accelerator model should out-perform the neoclassical model.[8] There are two possible explanations that come to mind. First, it could be that although the aggregate production function is neoclassical, it is not Cobb-Douglas. Actually, there is empirical evidence available for Australia pointing in this direction.[9] Second,

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7. Typical of our results is the following equation based on a Koyck-lag structure:

$$y_I = \underset{(1.15)}{84.654} - \underset{(-1.88)}{0.0007}\,\Delta(py/w_K) + \underset{(15.47)}{0.9047}\,y_{IN(-1)}$$

$$+ \underset{(24.69)}{0.0237}\,x_K$$

$$\bar{R}^2 = 0.9486 \qquad DW = 2.00$$

$y_I$ is gross investment, $y_{IN}$ is net investment, and $x_K$ is the beginning-of-period capital stock. The equation was estimated by OLS with quarterly data (seasonally adjusted) for the period 1963:I-1983:I.

8. The flexible accelerator and the neoclassical models are sometimes viewed as competing models, but the only difference between them concerns the underlying production function: Leontief in the former, Cobb-Douglas in the latter.

9. See Kohli (1983b). Eisner and Nadiri (1968) criticise Jorgenson for assuming that the elasticity of the desired capital stock with respect to its real rental price is unity.

and maybe more importantly, it could be that although the production function is neoclassical (whether Cobb-Douglas or not), the model has not been put to proper use. The neoclassical model, as set up by Jorgenson, predicts that a decrease in the relative rental price of capital will lead to an increase in the demand for capital services, and hence to increased investment. This proposition is only meaningful if the rental price of capital is exogenous, and if the stock of capital is endogenous. However, one can make a strong case that it is the reverse that is true in the aggregate. The stock of capital is given at any point in time, and under competitive conditions, the rental price of capital will tend to equal its marginal product. Hence, one can argue that the role of the production function is not to determine the demand for capital services, but rather to determine the equilibrium rental price of capital ($w_K^*$):

$$w_K^* = \alpha py/x_K \tag{2}$$

where $x_K$ is the actual (beginning-of-period) capital stock. (2) can be viewed as an inverse demand for capital services. The actual rental price of capital can then be assumed to be a distributed lag function of $w_K^*$. Estimation of the resulting equation, under alternative dynamic specifications, gives some very encouraging results.[10] In particular, the implied estimate of $\alpha$ is systematically found to be quite close to its theoretical value.

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10. A sample of our results is provided by the following equation (a partial adjustment mechanism is assumed, and the equation is estimated in terms of first differences to facilitate comparison with the estimates reported in footnote 7):

$$\Delta w_K = \underset{(-1.68)}{-0.0003} + \underset{(5.37)}{0.2415}\ \Delta(py/x_K) - \underset{(-3.09)}{0.2869}\ \Delta w_{K(-1)}$$

$\bar{R}^2 = 0.3428$ DW = 1.87

The equation appears to be well behaved. The fact that the speed of adjustment is greater than unity is somewhat odd, but need not be of great concern to us. The goodness of fit is rather low, but this is not surprising given that the dependent variable is a first difference. Moreover, the fit could undoubtedly be improved by relaxing the assumption of a Cobb-Douglas production function. Note that use of an inverse demand for capital function is made in RBA76 [Jonson et al. (1977)] to explain investment.

Investment affects the future values of the stock of capital, but the change in the capital stock cannot be deduced from the production function if the rental price of capital is endogenous. What then determines investment? One possible answer has been provided by Tobin (1969). According to Tobin, investment will take place whenever the shadow price of capital (Tobin's q) exceeds the market price of new investment goods (the price of output in Tobin's model). The shadow price of capital depends primarily on the demand for capital as an asset, which itself is likely to be a function of the rental price of capital. Thus, there is a link between the production function and the decision to invest, but it is much less direct than it is sometimes thought.

As noted previously, the 1970's were marked in Australia by a substantial increase in real wages, thus making the use of capital services relatively more attractive. The fact that investment did not increase, however, is not incompatible with the neoclassical model. On the contrary, properly applied neoclassical theory suggests that for given capital stock, an exogenous increase in real wages leads to a reduction in the real rental price of capital. This makes the ownership of capital less attractive, it decreases its shadow price, and, by the same token, it reduces incentives to produce and to install additional capital goods. Besides decreasing investment, the exogenous increase in real wages also tends to reduce output and employment, in the short run as well as in the long run. All three predictions are consistent with recent Australian history.

It seems at this stage that one possible way of proceeding is to formulate an investment function along the lines suggested by Tobin to complement (2). At the same time it would probably be worthwhile to relax the assumption of a Cobb-Douglas production function, i.e. (2) could be replaced by a more general formulation. One difficulty with Tobin's approach, however, is his assumption that the price of existing capital goods will tend to exceed the price of new capital goods. Tobin invokes the existence of adjustment and installation costs, but these costs are not accounted for by the model.

Tobin's approach, of course, is motivated by the desire to explain investment within the framework of a single-sector production model,[11] but it seems to us that it is preferable at this stage to relax the assumption of a single output. In what follows we therefore assume two outputs: investment goods and other (e.g. consumption) goods. At the same time we will also examine the question of the pricing of capital goods within a portfolio framework.

## 3. An Integrated Model of Investment Behaviour

In this section we discuss a fairly simple model of investment behaviour based on neoclassical theory and which seems broadly consistent with the facts, particularly with the developments of the seventies and early eighties. We give special attention to three major decisions linked with investment and capital: the decision to own capital goods, the decision to use capital goods, and the decision to produce capital goods. By the same token, we are led to distinguish between three important variables related to the decisions listed above: the price of capital, the rental price of capital, and the return on capital. The discussion follows the broad lines of Foley and Sidrauski's (1970) work, and it can be set in a two-input, two-output framework. Generalisation can be undertaken at a later stage.

The paper adopts the assumption that the stock of any commodity remains equal to its beginning-of-period value until the last instant of the period. It then rises to its recorded end-of-period value. This assumption is also applied to interest rates. Implicit price deflators are averages for the period but are assumed to be constant for the whole of each period in order to be consistent with the treatment of other variables. Investment and output are flows over the period.

It might be preferable to adopt the approach whereby variables are "centred" in each period. Further development of the model will explore such an alternative construction.

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11. Without ad hoc assumption of adjustment or installation costs, investment may be undetermined in a one-sector model. See Turnovsky (1977), for instance.

We assume an economy that uses two factors of production - capital and labour - to produce two goods - investment goods and consumption goods. We assume that capital and labour are homogeneous and mobile between firms. Let $x_N$ be the input of labour services, and let $w_N$ be the rental price of labour. We denote the outputs of investment goods and consumption goods by $y_I$ and $y_C$ respectively; $p_I$ and $p_C$ are the corresponding prices. Let T be the production possibility set, i.e. the set of all feasible input and output combinations. We assume that T is a convex cone. Assuming that profit maximisation takes place, the aggregate technology can be represented by a gross domestic product (GDP) function defined as follows:[12]

$$\pi(p_I, p_C, x_K, x_N) = \max_{y_I, y_C} [p_I y_I + p_C y_C:$$

$$(y_I, y_C, x_K, x_N) \in T; \; y_I, y_C \geq 0] \tag{3}$$

for $p_I, p_C \geq 0$ and $x_k, x_N > 0$. Given the assumptions about T, $\pi(.)$ is linearly homogeneous, nondecreasing and convex in output prices, and linearly homogeneous, increasing, and concave in input quantities.

The description of the technology by a GDP function makes it easy to derive the profit maximising supply of output and inverse demand for input functions. Of particular interest to us are the supply of investment goods and the inverse demand for capital services. Hotelling's (1932) lemma implies that:[13]

$$Y_I = \partial\pi(.)/\partial p_I = y_I(p_I, p_C, x_K, x_N) \tag{4}$$

and similarly:

$$w_K = \partial\pi(.)/\partial x_K = w_K(p_I, p_C, x_K, x_N) \tag{5}$$

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12. See Diewert (1974) and Kohli (1978).

13. Diewert (1974).

The supply of consumption goods and the inverse demand for labour services could be obtained in the same way.[14] The homogeneity of $\pi(.)$ implies that $y_I(.)$ is homogeneous of degree zero in prices and linearly homogeneous in quantities, while the reverse is true for $w_K(.)$. Furthermore, the curvature properties of $\pi(.)$ imply that $\partial y_I/\partial p_I \geq 0$ and $\partial w_K(.)/\partial x_K < 0$, i.e. the investment good supply schedule is upward sloping (or at least not downward sloping), and the inverse demand for capital services is negatively sloped.

The description of the technology by a GDP function is very convenient whenever one views input quantities and output prices as exogenous.[15] We will indeed assume that the capital stock and employment are given at any point in time, and the price of consumption goods will be assumed exogenous as well.[16] As to the price of investment goods, we assume that it is determined outside the production model by a process yet to be described. Note that we do not assume that production is non-joint in input quantities, i.e. that the two outputs are produced by separate production functions.[17] Non-jointness plays an important role in many areas of economics, for instance in growth theory and international trade theory; it leads to a number of remarkable results, such as the Stolper-Samuelson and the Rybczynski theorems, but it need not be invoked to derive (4)-(5), and it is not needed for our empirical work.[18]

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14. The linear homogeneity of $\pi(.)$ implies that $\pi(.) = p_I y_I + p_C y_C = w_K x_k + w_N x_N$

15. Thus the GDP function is particularly useful for international trade theory; see Kohli (1978, 1983c) and Woodland (1982).

16. The price of consumption goods would become endogenous if the model were closed by addition of a consumption function.

17. For a discussion of non-jointness, see Kohli (1983a). Note that Foley and Sidrauski (1970) do assume non-joint production.

18. A production model similar to the one considered here, but assuming non-jointless, has been estimated for the United States by Kohli (1981).

It is worth pointing out that (5) is very similar to (2) above. The main differences are that we have chosen here to treat employment as a fixed input,[19] and, of course, $w_K(.)$ is now a function of two price variables. The inclusion of labour as a fixed input, and the fact that our data are uncorrected for technological change may lead to some difficulties in our empirical work. A convenient way of handling these is to include a time trend in the estimating equations.[20]

Equations (4) and (5) determine the supply of investment goods and the rental price of capital, given factor endowments and output prices. The flow of new capital goods will, of course, bring about changes in the capital stock over time as

$$x_{K(+1)} = y_I + (1-\delta)x_K \tag{6}$$

where $x_{K(+1)}$ is the end-of-period stock of capital (the stock at the beginning of the following period), and $\delta$ is the rate of depreciation of capital.

In this model investment is viewed as being supply determined. Given the production possibility set, the investment flow simply depends on the relative price of capital goods. A similar view, albeit in a one-sector model context, is held by Tobin (1969).

An important question that must now be answered is what determines the price of investment goods? So far we have looked at two decisions related to capital: the decision to utilise existing capital services, and the decision to produce additional capital goods. We must now look at a third important decision: the decision to own existing capital goods. This question can best be examined within a portfolio framework.

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19. Alternatively, one could assume that $w_N$ is exogenous and that $x_N$ is endogenous; see Kohli (1983b).

20. This specification is consistent with the assumption of Harrod-neutral technological change; see Kohli (1981, 1983b).

We assume three assets: capital goods, money, and bonds.[21] New capital goods are assumed to be perfect substitutes for existing ones, hence the price of existing capital goods is $p_I$. Let W be beginning-of-period wealth:

$$W = p_I x_K + M + B \tag{7}$$

where M and B are the beginning-of-period stocks of money and (unit-price) bonds respectively.

Standard portfolio theory[22] suggests the following beginning-of-period demand for capital:

$$x_K p_I/p = h(r_K, r_M, r_B, y, W/p) \tag{8}$$

where y is real income. The demand for the ownership of capital is expressed in real terms; p is a general price index. (Alternatively $p_C$ could be used as a deflator). h(.) is a function of the rates of return on capital ($r_K$) and on the alternative assets ($r_M$, $r_B$), as well as on income and real wealth. The risk elements are assumed constant and imbedded in h(.). The demand for the ownership of capital is assumed to be non-decreasing in $r_K$; furthermore, it is reasonable to assume that h(.) is homogeneous of degree zero in interest rates, and linearly homogeneous in income and wealth.

The demands for the other assets can be expressed in a similar way.[23] In the case of money, for instance, we have:

$$M/p = k(r_K, r_M, r_B, y, W/p) \tag{9}$$

Naturally one would expect $\partial k(.)/\partial r_M \geq 0$.

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21. In a world of many assets (and liabilities), one could assume that capital, money, and bonds are separable from all other items.

22. See Tobin (1958), Foley (1975).

23. Note that all three asset demand functions must add up to beginning-of-period wealth; Foley (1975).

The rate of return on capital ($r_K$) is closely related to the rental price of capital. It can be calculated as follows:

$$r_K = w_K/p_I - \delta + \pi_I \qquad (10)$$

where $\pi_I$ is the expected change in the price of investment goods. For simplicity, we use the actual change in the price of investment goods to proxy $\pi_I$. For given $w_K$ and $x_K$, equations (8) and (10) simultaneously determine $r_K$ and $p_I$, i.e. portfolio equilibrium can be viewed as determining the price of capital goods.[24]

The full model of investment behaviour that we propose thus consists of three behavioural relationships - equations (4), (5), and (8) - and three technical relationships - equations (6), (7), and (10). Together these six equations can be used to determine $p_I$, $w_K$, $r_K$, $y_I$, $x_{K(+1)}$ and W. In view of (6) it is a dynamic system. (9) can be added to the model and used to endogenise M, $r_M$ or $r_B$.

The model of equations (4)-(10) can be used to calculate the short-run and long-run effects of changes in the exogenous variables. The formal mathematical derivation of short-run and long-run multipliers in a dynamic system is rather tedious, however, and we prefer to address these issues and the question of stability with the help of dynamic simulations once that the model has been estimated. This is undertaken in Section 5 below.

## 4. Empirical Results

We now discuss the empirical implementation and estimation of investment function (4), as well as of the accompanying behavioural equations (5), (8) and (9). The data are described in an appendix and the sample period is 1963:I-1983:I.

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24. See Sharpe (1964) for a theory of the pricing of assets. Note, however, that $w_K$ is itself a function of $p_I$; see equation (5).

A loglinear functional form is used for all four behavioural equations.[25] Furthermore, we make allowance for a partial adjustment mechanism, and a time trend (t) is included in each equation. We therefore have:[26]

$$\log y_I = \alpha_0\lambda_1 + \alpha_1\lambda_1 \log p_I + \alpha_2\lambda_1 \log p_C + \alpha_3\lambda_1 \log x_K + \alpha_4\lambda_1 \log x_N + \alpha_5\lambda_1 t + (1-\lambda_1)\log y_{I(-1)} \tag{11}$$

$$\log w_K = \beta_0\lambda_2 + \beta_1\lambda_2 \log p_I + \beta_2\lambda_2 \log p_C + \beta_3\lambda_2 \log x_K + \beta_4\lambda_2 \log x_N + \beta_5\lambda_2 t + (1-\lambda_2)\log w_{K(-1)} \tag{12}$$

$$\log(x_K p_I/p) = \gamma_0\lambda_3 + \gamma_1\lambda_3 r_K + \gamma_2\lambda_3 r_M + \gamma_3\lambda_3 r_B + \gamma_4\lambda_3 \log y + \gamma_5\lambda_3 \log(W/p) + \gamma_6\lambda_3 t + (1-\lambda_3)\log(x_K p_I/p)_{-1} \tag{13}$$

$$\log(M/p) = \delta_0\lambda_4 + \delta_1\lambda_4 r_K + \delta_2\lambda_4 r_M + \delta_3\lambda_4 r_B + \delta_4\lambda_4 \log y + \delta_5\lambda_4 \log(W/p) + \delta_6\lambda_4 t + (1-\lambda_4)\log(M/p)_{-1} \tag{14}$$

To add more structure to the model, the following restrictions can be imposed:

$$\alpha_1+\alpha_2 = 0; \quad \beta_1+\beta_2 = 1 \qquad \text{(price homogeneity)} \tag{15}$$

$$\alpha_3+\alpha_4 = 1; \quad \beta_3+\beta_4 = 0 \qquad \text{(quantity homogeneity)} \tag{16}$$

$$\gamma_1+\gamma_2+\gamma_3 = 0; \quad \delta_1+\delta_2+\delta_3 = 0 \qquad \text{(interest homogeneity)} \tag{17}$$

$$\gamma_4 + \gamma_5 = 1; \quad \delta_4 + \delta_5 = 1 \qquad \text{(income \& wealth homogeneity)} \tag{18}$$

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25. Alternatively, we could have a more general functional form such as the translog. However, this was not done for the sake of simplicity, and to keep the adjustment process as simple as possible.

26. We also experimented with the Almon (1965) technique, but we did no persist in that direction because of the difficulty of imposing linear homogeneity and symmetry in the presence of distributed lag functions.

Furthermore, symmetry of the Hessian of $\pi(.)$ implies that $\partial y_{I(.)}/\partial x_K = \partial w_K(.)/\partial p_I$.[27] This suggests that the following restriction be imposed at the mean of the sample:

$$\beta_1 = \alpha_3 \, s_I/s_K \tag{19}$$

where $s_I$ and $s_K$ are the shares of investment goods and capital in GDP. Similarly, interest symmetry implies:

$$\delta_1 = \gamma_2 \sigma_K/\sigma_M \tag{20}$$

where $\sigma_K$ and $\sigma_M$ are the shares of capital and money in wealth.

Finally, it is sensible to assume that the speeds of adjustment in the production model on one hand, and in the portfolio model on the other hand are the same.[28] Thus:

$$\lambda_1 = \lambda_2; \quad \lambda_3 = \lambda_4 \tag{21}$$

Empirical estimates of equations (11) and (12) are set out in Table 1. The two equations are estimated with the algorithm proposed by Berndt, Hall, Hall, and Hausman (1974) which allows the estimating equations to be non-linear in the parameters. Hence we obtain estimates of the long-run elasticities and of the speeds of adjustment directly.

The estimates reported in the first three columns are single-equation estimates, and those in the last two columns are joint estimates. Equations (11) and (12) are first estimated without restrictions (column 1); restriction (15) followed by (16) is next imposed (columns 2 and 3). The two equations are then estimated jointly (column 4),[29] and

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27. This is equivalent to Samuelson's (1947) reciprocity conditions.

28. In the case of the portfolio model, this is necessary if all assets are to be treated the same, and if only the own asset disequilibrium term is included; for a more general treatment, see Kohli and McKibbin (1982).

29. The joint estimation allows for the error terms of the two equations to be correlated.

finally (19) and (21) are imposed as well (column 5). It can be seen from Table 1 that the goodness of fit is very high in all cases, and that the estimated equations satisfy all regularity conditions ($\alpha_1 \geq 0$, $\beta_3 < 0$). The estimates of $\alpha_3$ seem rather large in absolute value, although once symmetry is imposed (column 5), $\alpha_3$ takes on a more plausible value. Actually the negative sign of $\alpha_3$ is extremely interesting. It indicates that an increase in the capital stock leads *ceteris paribus* to a fall in the

Table 1
Parameter Estimates - Production Model
1963:I - 1983:I
(t values in parentheses)

| Parameters | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | | | Supply of Investment Goods | | |
| $\alpha 0$ | 35.9330 | 28.0430 | 16.9937 | 18.0413 | 6.6401 |
| | (1.77) | (1.30) | (2.88) | (2.91) | (2.78) |
| $\alpha 1$ | 0.8323 | 0.5279 | 1.3600 | 1.4595 | 0.2805 |
| | (0.59) | (0.32) | (1.55) | (1.55) | (0.44) |
| $\alpha 2$ | -1.3755 | $-\alpha 1$ | $-\alpha 1$ | $-\alpha 1$ | $-\alpha 1$ |
| | (-0.88) | | | | |
| $\alpha 3$ | -6.6490 | -7.5456 | -7.1292 | -7.5458 | -2.9938 |
| | (-3.17) | (-3.00) | (-3.13) | (-3.03) | (-3.14) |
| $\alpha 4$ | 5.1218 | 7.3479 | $1-\alpha 3$ | $1-\alpha 3$ | $1-\alpha 3$ |
| | (1.92) | (2.85) | | | |
| $\alpha 5$ | 0.0492 | 0.0347 | 0.0277 | 0.0291 | 0.0130 |
| | (2.59) | (2.26) | (3.46) | (3.33) | (3.77) |
| $\lambda 1$ | 0.2411 | 0.2041 | 0.2094 | 0.1959 | 0.2396 |
| | (3.74) | (3.73) | (3.87) | (3.69) | (5.04) |
| $R^2$ | 0.9631 | 0.9626 | 0.9624 | 0.9624 | 0.9598 |
| DW | 2.38 | 2.43 | 2.43 | 2.47 | 2.22 |
| | | | Inverse Demand for Capital Services | | |
| $\beta 0$ | 15.6552 | -11.1517 | 7.1143 | 6.9400 | 1.8482 |
| | (1.11) | (-0.65) | (1.76) | (1.93) | (0.40) |
| $\beta 1$ | 0.6939 | 0.7540 | -0.7256 | -0.7634 | $0.80\alpha 3$ |
| | (0.68) | (0.49) | (0.97) | (1.11) | |
| $\beta 2$ | -0.6119 | $1-\beta 1$ | $1-\beta 1$ | $1-\beta 1$ | $1-\beta 1$ |
| | (-0.55) | | | | |
| $\beta 3$ | -3.7544 | -3.6618 | -4.1197 | -4.0523 | -2.0046 |
| | (-3.59) | (-2.35) | (-2.63) | (-2.83) | (-1.09) |
| $\beta 4$ | 2.4263 | 5.7112 | $-\beta 3$ | $-\beta 3$ | $-\beta 3$ |
| | (1.45) | (2.69) | | | |
| $\beta 5$ | 0.0366 | 0.0012 | 0.0123 | 0.0120 | 0.0043 |
| | (2.74) | (0.11) | (2.16) | (2.31) | (0.64) |
| $\lambda 2$ | 0.4430 | 0.3076 | 0.3018 | 0.3290 | $\lambda 1$ |
| | (4.64) | (3.79) | (3.70) | (4.11) | |
| $R^2$ | 0.9867 | 0.9857 | 0.9855 | 0.9855 | 0.9847 |
| DW | 2.06 | 2.20 | 2.16 | 2.09 | 2.20 |

output of investment goods.[30] By the same token, an increase in employment must, under constant returns to scale, increase the output of investment goods by relatively more. An implication of this result is that an increase in the price of investment goods should reduce the rental price of capital.[31] As shown by the estimates of $\beta_1$ reported in Table 1, this is indeed the case once constant returns to scale are assumed. (The estimates of $\beta_1$ shown in columns 1 and 2 are positive, but not significantly so.)

Estimates of equations (13)-(14) are shown in Table 2. Here also we start with the unconstrained versions (column 1). We then proceed to impose in turn interest homogeneity [restriction (17) - column 2], and income and wealth homogeneity [restriction (18) - column 3], before estimating the two equations jointly (column 4), and finally imposing symmetry and equal speeds of adjustment [restrictions (20) and (21) - column 5]. We can see from Table 2 that both asset demand equations are well behaved ($\gamma_1 \geq 0$ and $\delta_2 \geq 0$) in all cases.

Interest-rate effects tend to be small, and they are insignificant in a number of cases. This is due to the collinearity between $r_K$, $r_M$, and $r_B$, and it is therefore desirable to impose as much structure as possible on the model. This is done with the help of the symmetry and homogeneity restrictions. Judging from the constrained estimates of column 5, capital, money, and bonds are all substitutes for one another. It is also worthwhile noting that the rate of return of capital has a significant effect on the demand for money in all cases. Yet this variable is generally excluded from demand for money functions.

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30. Since non-joint production is not assumed the Rybczynski theorem does not hold, i.e. it is not necessary for the supply of one output to fall when the endowment of one factor is increased. The fact that this happens in our model is a coincidence. If this were a two-sector model, we could conclude that the investment good sector is relatively labour intensive. [This is Foley and Sidrauski's (1970) assumption, and it is consistent with empirical evidence for the United States, see Kohli (1981)].

31. Samuelson's (1947) reciprocity conditions once again.

Table 2
Parameter Estimates - Portfolio Model
1963:I - 1983:I
(t values in parentheses)

| Parameters | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Demand for capital | | | | |
| $\gamma 0$ | -6.0040 | -0.3852 | -2.3325 | -2.3073 | -2.4759 |
| | (-2.08) | (-0.16) | (-6.72) | (-7.03) | (-7.34) |
| $\gamma 1$ | (0.0046 | 0.0046 | 0.0050 | 0.0049 | 0.0059 |
| | (3.76) | (3.28) | (3.42) | (3.53) | (4.13) |
| $\gamma 2$ | 0.0094 | 0.0031 | 0.0020 | 0.0019 | -0.0021 |
| | (1.59) | (0.48) | (0.30) | (0.30) | (-2.82) |
| $\gamma 3$ | 0.0028 | | | | |
| | (0.46) | $-\gamma 1-\gamma 2$ | $-\gamma 1-\gamma 2$ | $-\gamma 1-\gamma 2$ | $-\gamma 1-\gamma 2$ |
| $\gamma 4$ | -0.7128 | -0.8517 | -0.9120 | -0.8991 | -0.9842 |
| | (-5.25) | (-4.91) | (-5.11) | (-5.33) | (-5.69) |
| $\gamma 5$ | 2.0661 | 1.6915 | $1-\gamma 4$ | $1-\gamma 4$ | $1-\gamma 4$ |
| | (6.48) | (5.67) | | | |
| $\gamma 6$ | -0.0006 | 0.0051 | 0.0043 | 0.0042 | 0.0044 |
| | (-0.29) | (3.94) | (6.33) | (6.62) | (7.60) |
| $\lambda 3$ | 0.3130 | 0.3115 | 0.2884 | 0.2939 | 0.2538 |
| | (5.57) | (4.86) | (5.10) | (5.40) | (6.44) |
| $R^2$ | 0.9982 | 0.9976 | 0.9976 | 0.9976 | 0.9976 |
| DW | 1.54 | 1.46 | 1.45 | 1.44 | 1.59 |
| | Demand for Money | | | | |
| $\delta 0$ | -10.8965 | -13.4861 | 1.0364 | 1.0234 | 0.9345 |
| | (-1.59) | (-2.04) | (2.13) | (2.22) | (2.44) |
| $\delta 1$ | -0.0061 | -0.0062 | -0.0053 | -0.0052 | $1.98\gamma_2$ |
| | (-2.36) | (-2.35) | (-2.26) | (-2.33) | |
| $\delta 2$ | 0.0023 | 0.0051 | 0.0148 | 0.0144 | 0.0115 |
| | (0.15) | (0.34) | (1.00) | (1.03) | (1.00) |
| $\delta 3$ | -0.0033 | | | | |
| | (-0.21) | $-\delta_1-\delta_2$ | $-\delta_1-\delta_2$ | $-\delta_1-\delta_2$ | $-\delta_1-\delta_2$ |
| $\delta 4$ | 0.9686 | 1.0285 | 1.0813 | 1.0759 | 1.0381 |
| | (3.77) | (4.10) | (4.38) | (4.60) | (5.29) |
| $\delta 5$ | 1.0583 | 1.2345 | $1-\delta 4$ | $1-\delta 4$ | $1-\delta 4$ |
| | (1.70) | (2.00) | | | |
| $\delta 6$ | -0.0102 | -0.0128 | -0.0042 | -0.0042 | -0.0040 |
| | (-2.100) | (-3.02) | (-4.27) | (-4.48) | (-5.14) |
| $\lambda 4$ | 0.1977 | 0.1954 | 0.2116 | 0.2167 | $\lambda 3$ |
| | (3.49) | (3.46) | (3.58) | (3.80) | |
| $R^2$ | 0.9926 | 0.9926 | 0.9916 | 0.9916 | 0.9916 |
| DW | 1.68 | 1.63 | 1.76 | 1.75 | 1.59 |

As one would expect, the income elasticity of the demand for money is positive, while the income elasticity of the demand for capital is negative.[32] On the other hand, the wealth elasticity of the demand for money is close to zero, while it is significantly positive for the demand for capital. The common estimate of the speed of adjustment (column 5) shows that about 25 per cent of the adjustment takes place within the period. This is approximately the estimate obtained for the production model (Table 1, column 5). We can also note that the fit is very good in all cases.

The estimates of equations (11)-(14) compare very favourably with the empirical results evoked in Section 2. Of course, of particular interest to us are the estimates of equation (11) since we are primarily interested in explaining investment. The fit obtained with equation (11) compares favourably with the fit obtained with other models of investment behaviour.[33] The actual and the fitted values of investment [equation (11), estimates of Table 1, column 1] are plotted in Figure 3. It can be seen that the fitted values track the observed values quite closely, and that (11) explains the major turning points which have occurred. Perhaps more important, though, is the fact that the estimated form of (11) is well behaved and consistent with the underlying theory. This is more than one can say about the traditional neoclassical investment function.

While the estimates of investment function (11) are of considerable interest, the main feature of our approach is that it is an integrated approach, i.e. a number of related decisions are being considered simultaneously. Equation (11) should therefore be viewed as an element of a system, and it is the full system that deserves most of our attention. One relatively painless way of looking at the properties of a

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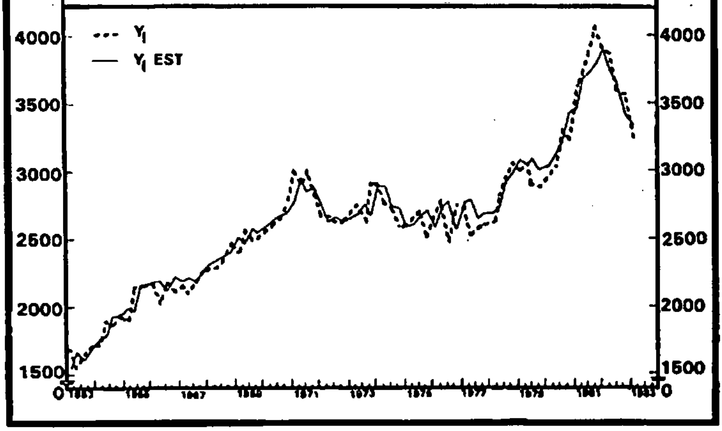
32. For given wealth, an increase in the demand for money can only come at the expense of at least one other asset.

33. If equation (11) is re-estimated in level form, rather than in logarithmic form, the R-bar squared is 9585.

FIGURE 3




system of equations is to undertake a number of simulations. This is the purpose of the next section. But prior to this, it is worthwhile to re-estimate equations (11)-(14) making allowance for the endogeneity of $w_K$, $p_I$, and $r_K$.

The method we use for the simultaneous estimation is full information maximum likelihood (FIML). Parameter estimates are reported in Table 3. They have been obtained subject to (15)-(21), and hence they are comparable to the estimates of column 5, Tables 1 and 2. Moreover, for the model to converge, we found it necessary to fix the values of two parameters, $\alpha_1$ and $\gamma_4$. The values which we used are respectively 1 and -1, and they were chosen on the basis of the results from Tables 1 and 2.[34]

The major differences between the estimates of Table 3 and those of Tables 1 and 2 concern the portfolio part of the model: interest-rate effects and the speed of adjustment are all substantially larger when the model is estimated by FIML.

34. It is not uncommon to have to fix a number of parameters when estimating a model by FIML; see Jonson et al. (1977) or Kohli and McKibbin (1982), for instance.

Portfolio adjustment is now two and a half times as fast as adjustment in the production sector. There is some evidence of complementarity between money and bonds judging from the positive sign of $\delta_3$, but the effect is weak and not significantly different from zero so that it should probably not be taken too seriously. Otherwise the parameter estimates seem to be little affected by the simultaneous estimation technique. It is interesting to note that the negative signs of $\alpha_3$ and $\beta_1$ are maintained.

<u>Table 3</u>
<u>Parameter Estimates - Full Model</u>
<u>FIML Estimation</u>

(t values in parantheses)

$$\log \hat{y}_I = \underset{(2.93)}{6.8854} + 1.0000 \log p_I - 1.0000 \log p_C - \underset{(-3.44)}{3.2607} \log x$$

$$+ \underset{(4.49)}{4.2607} \log x_N + \underset{(5.37)}{0.0218t}$$

$$\log \hat{w}K = \underset{(0.55)}{2.4581} - \underset{(-3.44)}{2.6085} \log p_I + \underset{(4.75)}{3.6085} \log p_C - \underset{(-1.32)}{2.3513} \log x$$

$$+ \underset{(1.32)}{2.3513} \log x_N + \underset{(1.59)}{0.0102t}$$

$$\log(\widehat{p_I \times K/p}) = \underset{(-23.89)}{-4.0792} + \underset{(6.42)}{0.0288r_K} - \underset{(-6.22)}{0.0073r_M} - \underset{(6.45)}{0.0215r_B} - 1.0000 \log$$

$$+ 2.0000 \log (W/p) + \underset{(11.77)}{0.0308t}$$

$$\log(\widehat{M/p}) = \underset{(12.47)}{2.2053} - \underset{(-6.22)}{0.0145r_K} + \underset{(1.65)}{0.0074r_M} + \underset{(1.57)}{0.0071r_B} + \underset{(18.04)}{1.3868} \log$$

$$- \underset{(-5.03)}{0.3868} \log (W/p) - \underset{(-13.57)}{0.0156t}$$

$$\log y_I = \underset{(5.28)}{0.2261} \log \hat{y}_I + \underset{(18.09)}{0.7739} \log y_I(-1)$$

$$\log wK = \underset{(5.28)}{0.2261} \log \hat{w}K + \underset{(18.09)}{0.7739} \log wK(-1)$$

$$\log(p_I \times K/p) = \underset{(10.47)}{0.5684} \log (\widehat{p_I \times K/p}) + \underset{(7.95)}{0.4316} \log (p_I \times K/p)_{-1}$$

$$\log(M/p) = \underset{(10.47)}{0.5684} \log (\widehat{M/p}) + \underset{(7.95)}{0.4316} \log (M/p)_{-1}$$

## 5. Simulation Results

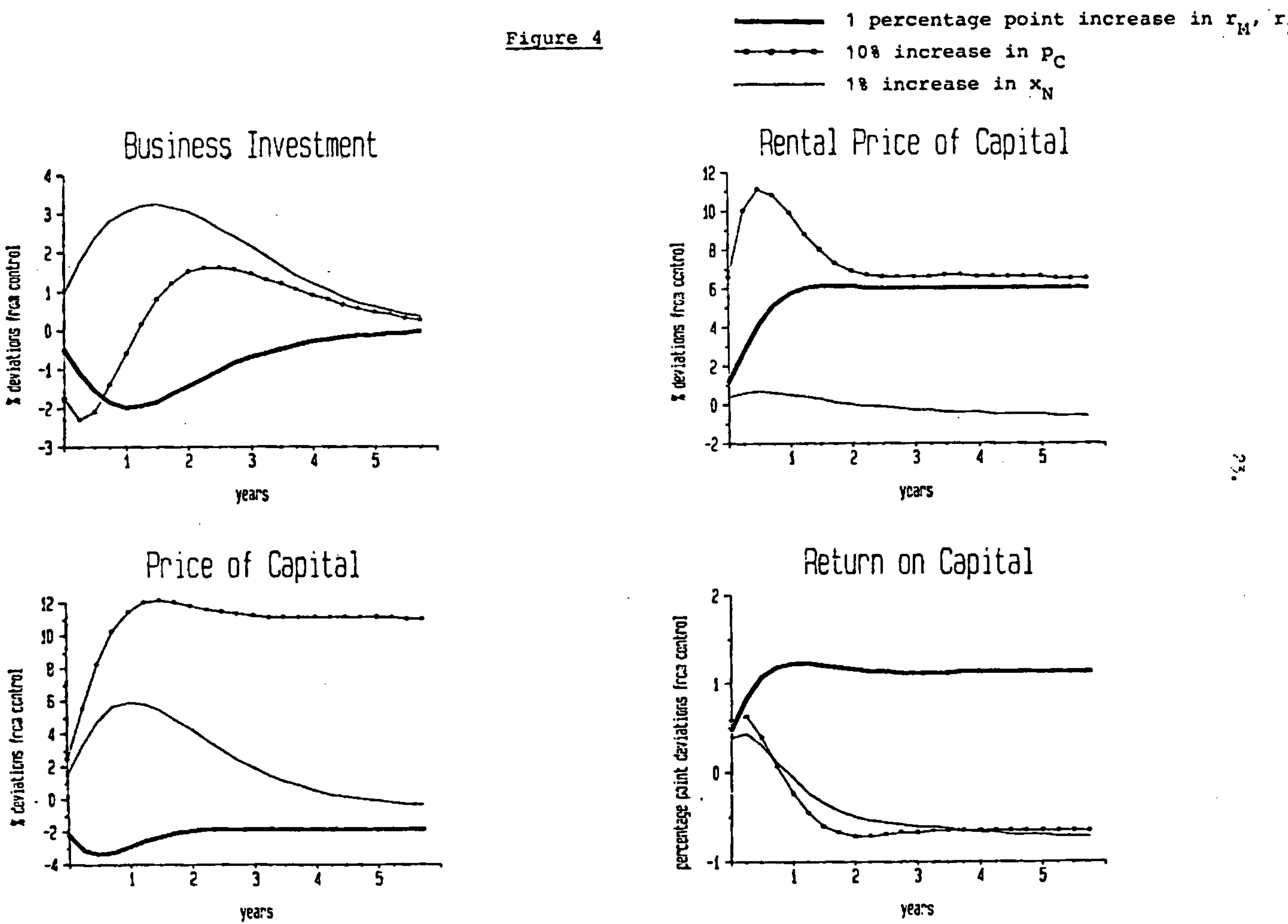
Three counterfactual simulations will serve to illustrate the properties of the model. We will consider in turn: 1) a sustained one percentage point increase in the bond and money rates; 2) a sustained 10 per cent increase in the price of consumption goods; 3) a sustained 1 per cent increase in employment.

For the purpose of the simulations, the model was linearised around sample means. This not only facilitates the simulation exercise, but it also guarantees that the simulation results are independent of the starting point. Furthermore, it was necessary to exogenise $\pi_I$ (in the definition of $r_K$) as it proved to be a source of instability. The modelling of expectations is an extremely delicate matter, and it is clear that our model leaves ample room for improvements in this respect. With this change the model is stable. The simulation results are presented in terms of graphs for the main variables of interest: $y_I$, $w_K$, $p_I$, and $r_K$. The behaviour of the other variables is evoked in the text.

The effect of an increase in $r_M$ and $r_B$ is to reduce the demand for capital goods (by making ownership less attractive), and hence, the supply being inelastic in the short run, the price of capital falls. (The drop in the price of capital actually dampens the decrease in demand by raising, <u>ceteris paribus</u>, the return on capital.) As a result the production of new capital goods falls, that is investment declines. One complicating factor arises because the production of investment goods involves the use of capital services. As indicated by the negative sign of $\beta_1$, the drop in the price of investment goods favours capital at the expense of labour. $w_K$ therefore increases, thereby lifting the return on capital. This further reduces the decline in demand, and hence the need for a fall in the price of capital goods. The bottom line is that the increase in interest rates has only a relatively small effect on investment once that allowance is made for endogenous adjustments in $p_I$, $w_K$ and $r_K$. As indicated by the first panel of Figure 4, investment falls to a value approximately 2 per cent below control (after 5 quarters) before starting to rise again. The increase that takes place after the fifth quarter reflects to a large extent the effect of the falling capital stock on the output of investment goods (negative sign of $\alpha_3$). In the long run, investment is only 0.1 per cent below control. The price of capital goods exhibits pretty much the same pattern. It is 3.3 per cent below control in the third quarter, but it gradually recovers as the supply of capital goods declines, and eventually it reaches a value about 1.8 per cent below control. The increase in the rate of return on capital and in its rental price take place fairly rapidly, and they are substantial: approximately 6 per cent for the latter, and over one percentage point for the former in the long run. The rise in interest rates is therefore more than offset by the increase in $r_K$. This result is explained by the drop in wealth that is caused by the fall in both $x_K$ and $p_I$.

An increase in the price of consumption goods tends to lead to a shift of resources from the production of investment goods to the production of consumption goods, that is investment tends to decline. However, this reallocation of resources favours capital over labour: the rental price of capital rises, hence the price of capital must increase for portfolio equilibrium to be maintained. The increase in the price of capital goods partially offsets the rise in the price of consumption goods, so that the effect on the production of capital goods is much reduced. Investment is 2.3 per cent below control after two quarters. However, the movement rapidly reverses itself under the influence of the falling stock of capital which affects the output of investment goods in two different ways: directly (through $\alpha_3$), and indirectly through further rises in the price of capital resulting from its increased scarcity. The increase in the price of capital goods actually rapidly exceeds the rise in the price of consumption goods, so that investment becomes larger than in the control solution. In the long run,

Figure 4



1 percentage point increase in $r_M$, $r_B$
10% increase in $p_C$
1% increase in $x_N$
Business Investment
% deviations from control
years
Rental Price of Capital
% deviations from control
years
Price of Capital
% deviations from control
years
Return on Capital
percentage point deviations from control
years

investment is fractionally above control.[35] $w_K$ has gone up by approximately 6.6 per cent, while $r_K$ has lost about two thirds of a percentage point.

A 1 per cent increase in employment has a powerful effect on investment since it favours the production of capital goods over the production of consumption goods. Moreoever, it results in an increase in the rental price of capital (since labour intensity increases). This translates itself in an increase in the price of capital goods (portfolio equilibrium obliging), which further stimulates investment. In the long run, the capital stock is 1.2 per cent above its control level, and investment exceeds its control solution by about 0.3 per cent. The return on capital is little affected by the shock.

To sum up the results from our simulations, it appears that Australian business investment is more sensitive to the level of activity (proxied here by employment) than to variations in interest rates and in the relative price of investment goods. This result is hardly surprising. Many researchers before us have failed to uncover significant links between interest rates and investment, and there seems to be widespread scepticism regarding their existence. It is noteworthy that the absence of any strong effect does not result from exceedingly small price and interest elasticities at the level of the individual behavioural relationships. Instead it is due to the interactions of a number of mechanisms which tend to neutralise the impact of external shocks. It is important therefore that variables such as the price of capital or its rental price be endogenised when assessing the effects of price or interest rate changes. Our results also suggest that tax measures aiming at making the use, ownership, or production of capital goods more attractive will have little lasting effects.[36]

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35. $y_I$ and $r_K$ return to control, while $p_I$ and $w_K$ increase by exactly 10 per cent in the long run if p and B are exogenously increased by the same percentage simultaneously with $p_C$. The simulation results are available on request.

36. Simulation results of several taxation experiments are available on request.

## 6. Concluding Comments

The model of Section 4 is, to the best of our knowledge, one of the first empirical applications of the theoretical literature on multiple-output growth models.[37] It is a complete model of investment behaviour, and it integrates production decisions and portfolio decisions. Although there is plenty of room left for improvement,[38] our empirical results are rather encouraging: the model is well behaved (once expectations are exogenised), the parameter estimates are plausible and in line with prior expectations, and the goodness of fit of the individual equations is highly satisfactory. Yet the approach that we have followed is unmistakenly neoclassical. It thus appears that the Australian facts are not in conflict with neoclassical theory.[39]

Neoclassical investment theory and the portfolio approach are sometimes viewed as competing theories of investment behaviour.[40] Our approach shows that this need not be the case. The two approaches merely focus on different aspects of the capital accumulation process (usership and ownership), and they are like the two sides of a coin. In fact, we have argued, there is a third dimension to it, since capital goods must also be produced. Moreover, all three aspects must be considered simultaneously if one wants to account for the endogeneity of the price and the rental price of capital.

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37. The theoretical literature originates with the work of Meade (1961) and Uzawa (1962). Subsequently, financial assets were brought into the analysis; see Foley and Sidrauski (1970), for instance. The empirical work of Engle and Foley (1975) only deals with the supply of investment goods, while Kohli (1978, 1981) only considers the production side of the model.

38. As noted earlier, it might be preferable to estimate the model as the discrete-time analogue to the continuous-time system.

39. The same view is expressed by Carmichael (1979). Carmichael actually argues in favour of an integrated approach to modelling investment.

40. See Feldstein (1982), for instance. Tobin's (1969) q theory, and Feldstein's rate of return theory could be included under the heading portfolio theory of investment.

The production model of Section 4 could be generalised to allow for more inputs and more outputs. Of particular relevance for an open economy like Australia would be the inclusion of imports and exports. Imports can be viewed as an input to the technology, and exports are an additional output. The treatment of imports as intermediate inputs is analytically convenient,[41] and it is justified by the fact that Australia imports many non-finished products. Moreover, most imported finished goods are still subject to domestic landing, transportation and retail charges before reaching final demand so that a significant proportion of the final price tag is accounted for by domestic value added. This is true for consumption goods as well as for investment goods. Australia imports many capital goods from overseas, but for analytical purposes one can view these goods as flowing through the domestic production sector and being combined with domestic capital and labour services in the process. The supply of investment goods would therefore become a function of the price of imports, and one would expect an increase in the price of imports to reduce investment, if Australia's output of investment goods is indeed import intensive. Similarly the supply of investment goods becomes a function of export prices, if exports are viewed as an additional output of the production sector.[42]

The above argument can be linked with the debate on the so-called resources boom.[43] Australia is a large exporter of mining products. We can safely assume that the capital requirements of the mining sector are relatively high. It then follows that an increase in the price of mining products (and in the price of exports to a large extent) results in an

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41. See Kohli (1978, 1983c).

42. Attempts to include the prices of imports and exports in (11)-(12) have not led to a significant improvement in the fit. This is probably due to the presence of multicollinearity between the price variables. The problem could be reduced by estimating the full system of demand and supply equations; Kohli (1978).

43. See Gregory (1976) for a theoretical discussion.

increase in the rental price of capital and consequently in the price of capital goods. This tends to increase the supply of investment goods and imports of machinery. The resources boom can be interpreted in this light: the relative price of exports did go up following sharp increases in world commodity prices in 1979/80, and no doubt even larger increases were anticipated. Australian investment and imports rose, but the trend suddenly reversed itself with the collapse of world commodity prices, and the resources boom failed to materialise, at least for the time being.

Of course the portfolio model of Section 4 could be expanded as well, with the inclusion of liabilities and additional assets. Of special interest would be bank advances and foreign liabilities;[44] this would enable us to bring financing issues into the analysis. The question of foreign borrowings is of course also closely linked to the debate on the resources boom. Investment in the mining sector taking place to a large extent in anticipation of increased exports, and Australia being a relatively small country, much of the financing must come from overseas. The effects of the resources boom on our integrated model of portfolio and production behaviour are therefore manifold. The portfolio aspects involve increases in holdings of capital largely offset by increased foreign liabilities. The production effects involve increases in the demand for imports and in the output of investment goods resulting over time in a larger input of capital services and additional exports.[45]

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44. See Kohli and McKibbin (1982), for instance.

45. Another aspect of the resources boom concerns the balance on invisibles with the interest payments on foreign liabilities. International trade theory usually assumes that (physical) capital is immobile internationally [although see Mundell (1957)]; international finance theory, on the other hand, often allows for international (financial) capital mobility [e.g. Mundell (1963)]. The approach that we outline is compatible with both views, including the notion that installed capital is not mobile. At the same time it allows for imports (and possibly exports) of capital goods.

One question that often arises concerns the employment effect of investment. A number of different views have been expressed in this area, with some commentators insisting on the job creation effect of investment and growth, and others more concerned with the job displacement effect of capital accumulation.[46] By treating employment as exogenous our model can only bring a partial answer to these questions. However, the estimates reported in Table 4 suggest that labour requirements of investment are relatively large, hence an increase in investment will tend to be accompanied by an increase in the (inverse) demand for labour.[47] Furthermore, the subsequent increase in the stock of capital, other things equal, will increase the marginal product of labour. Of course, one can argue that the entire debate is a red herring. Full employment is consistent with any output mix. What is required for full employment is that the economy operates on the production possibility frontier; this can be achieved even if all output is consumed, that is if investment is nil. Moreoever, one can argue that, in the long run, investment has little to do with economic growth. Elementary growth theory teaches us that the steady-state growth rate is independent of the savings ratio.[48] Hence the conclusion that taxation can do little to affect investment in a durable way should not cause policy makers any undue distress.

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46. See Hawkins (1979), for instance.

47. Although if investment and employment are both viewed as endogenous, one cannot exclude the possibility that certain exogenous shocks will have opposite effects on these two variables.

48. Of course, the savings ratio is crucial in determining steady-state capital intensity, income, and relative factor prices.

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# DATA APPENDIX*

$B$ — Private non-bank holdings of government securities (at face value).
Source: Reserve Bank

$M$ — Currency plus total deposits at all trading banks plus total deposits at all savings banks (M3).
Source: (1) Table A.3, Volume of Money

$p$ — Implicit price deflator for expenditure on gross domestic product.
Source: (2)

$p_c$ — Implicit price deflator for private final consumption expenditure.
Source: (2)

$p_I$ — Implicit price deflator for gross fixed capital expenditure on non-dwelling construction and equipment.

$p_I$ = nominal $Y_I/Y_I$
where $Y_I$ is defined below

$r_B$ — Theoretical yield on 10 year non-rebate Australian government securities.
Source: (1), Table J.3, Yields on Government Securities.

$r_k$ — Rate of return on capital

$$r_k = (w_k + \Delta p_I)/p_I - \delta$$

where $w_k$ is defined below
$\delta$ is the rate of depreciation of capital stock (=2.38% per quarter)

$r_m$ — Proxy for the rate of return on money. Equals the interest rate on trading banks fixed deposits under $50,000 between 3 and 6 months. (Minimum of the range.)
Source: (1), Table J.1, Bank Interest Rates

$W$ — Beginning-of-period wealth
$W = p_I . x_k + M + B$
where $x_k$ is defined below.

$w_k$ — Rental price of capital (user cost)

$$w_k = (YGOSC+YGOSFE)/x_k$$

where YGOSC is the gross operating surplus of companies. Source (2)
YGOSFE is the gross operating surplus of financial enterprises less imputed bank service charge. Source (2)

$w_N$ — Nominal wage rate per quarter

$$w_N = YWSS/x_N$$

where YWSS is wages, salaries and supplements. Source (2)
and $x_N$ is defined below.

$x_k$ Stock of capital

$$x_{k+1} = (1-\delta)\, x_k + Y_I$$

(the end-of-June quarter, 1979 value is \$99,057 million)

$Y_I$ is defined below.

$x_N$ Employment
Source: The Labour Force, Australia. ABS 6202.0, March 1983
Data before 1966(3) constructed within the Reserve Bank using disaggregated data.

$Y$ Gross domestic product.
Source (2)

$Y_I$ Business gross fixed capital expenditure
$Y_I$ = gross fixed capital expenditure on non-dwelling construction (Source: (2))
plus gross fixed capital expenditure on equipment (Source: (2))
data adjusted within the Reserve Bank to take out the effects of all lease-back arrangements to date.

$Y_{IN}$ Net investment

$$Y_{IN} = x_{k+1} - x_k = Y_I - \delta . x_k$$

* All data are seasonally adjusted where appropriate.

(1) Statistical Bulletin. Sydney: Reserve Bank of Australia, monthly.

(2) Quarterly Estimates of National Income and Expenditure (5206.0) Canberra: Australian Bureau of Statistics, March quarter, 1983.